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AFAL-TR-75-46

LIGHTWEIGHT IR DISPENSER
(PERCUSSION TYPE)
FINAL ENGINEERING REPORT

Lundy Electronics & Systems, Incorporated
Lundy Technical Center
Pompano Beach, Florida 33064

TECHNICAL REPORT AFAL-TR-75-46

SEPTEMBER 1975

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Prepared for

Air Force Avionics Laboratory
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Air Force Systems Command
Wright-Patterson Air Force Base, Ohio 45433

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A low cost, lightweight countermeasures dispenser, suitable for use on Forward Air Control (FAC) aircraft and helicopters was designed, built and successfully flight tested.

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AFAL
FOREWORD

The objective of this contract was to design, develop, fabricate and qualify a lightweight IR Dispenser for use in FAC aircraft. The introduction of the SA-7 SAM in the southeast Asia area has resulted in a vital threat to low altitude, slow speed, FAC type aircraft. This could lead to serious degradation of the FAC role, i.e., tracking at higher altitudes, doubling coverage and evasive/maneuvers foreign to normal combat flying. Present countermeasures against this threat consist of maneuvers/evasive action coupled with firing of IR flare from a Very-Pistol by the flight crew. This results in inadequate flare dispensing, multi-utilization of crew, inadequate coverage, etc. Present flares and dispensing systems are too large, too heavy, and too costly for utilization on FAC type aircraft. In addition, the present flare possesses a larger IR radiation intensity that is presently needed.

The output of this effort resulted in a complete system (dispenser and programmer) weighing 19.0 lbs. and carrying 20 flares per module. The programmer weighing 2.0 lbs. occupies a space 3.0" high x 5.0" wide x 5.0" deep. The dispenser unit 6.2" high x 8.0" wide x 9.50" deep, carries 20 flares weighing 0.44 lbs. each. The complete system loaded with flares weighs 27.4 lbs. In addition, this system can be utilized either in an external or internal installation. Proper shields and fairing have been developed for the external installation. The use of a cascade switch in the programmer allows the programmer to handle up to five dispenser units operating in series or parallel, thus giving it a capability of handling up to 100 flares.

This system because of its weight, size and cost should be seriously considered for utilization in all low/slow aircraft and with its series/parallel capability is quite adequate for MAC type weapon systems.

Flight tests of this system with the Navy MK-50 flare, at ADTC against the "Have Cake" showed 100% break-lock ability. No malfunctions of the system occurred and the flight tests were completed in two days.

To increase the utilization of this equipment, chaff units are being developed to give the system a dual capability.

The cooperation and contract effort received from the contractor were excellent. All scheduling dates were met, equipment delivered for flight tests were on time, and field engineering support far exceeded that expected.

This technical report has been reviewed and is approved for publication.

George W Schivley
GEORGE W. SCHIVLEY
431G Project Engineer
ECM Advanced Development Branch
Electronic Warfare Division

FOR THE DIRECTOR

Ollie H. Edwards
OLLIE H. EDWARDS
Colonel, USAF
Chief, Electronic Warfare Division
Air Force Avionics Laboratory

FOREWORD

This technical report documents work performed by Lundy Electronics & Systems, Incorporated, 3901 N. E. 12th Avenue, Pompano Beach, Florida 33064 during the period 1 February to 31 December 1974 under Contract Number F33615-74-C-1138 with the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio. This program was monitored by George W. Schivley (WRD-2).

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Section I
INTRODUCTION

This report describes a percussion type flare dispenser designed for use on FAC aircraft. The dispensing system is lightweight, compact and reasonable in both acquisition and operating cost so as to be consistent with the operational role of FAC aircraft.

The overall dispensing system design requirements were:

a) Capable of installation on the O-1, O-2, OV-10, and other lightweight aircraft
b) Compatibility with the Navy MK-50 percussion type Flare Decoy
c) Five hundred dollar ($500) unit cost per system in production quantities
d) Twenty (20) flare capacity
e) Variable dispensing sequence
f) Downward ejection of expendables
g) Payload module jettison or ripple fire capability
h) Modular or individual flare loading
i) Common mounting provisions
j) Single point electrical interface
k) Rapid transition from development through production

The program activities included a Phase I and Phase II effort, that culminated with the delivery of three "brassboard" systems for flight testing. The specific Phase I requirements (initial sixty days of the program) were to develop a preliminary design for the system hardware, carry out an installation/location investigation on candidate aircraft and perform a preliminary safety analysis.

The Phase II effort included equipment design, hardware fabrication, system assembly, functional ground tests, acceptance tests, and support of flight tests performed at Eglin Air Force Base.

Section II
SYSTEM DESIGN
Phase I Summary

The Phase I tasks included the preliminary design, an installation/location study and a safety design analysis.

The dispenser assembly design included sub-tasks for the housing, modules and firing mechanism designs. Engineering models of the firing mechanism and flare modules were fabricated and evaluated to develop preliminary design data. The control display unit design was broken down into three sub-tasks; PC board, control panel and components packaging.

The 0-1, 0-2 and OV-10 aircrafts were inspected by Lundy personnel at various Air Force installations to determine interface, mounting and location requirements. The information gathered during these visits resulted in several specific installation recommendations.

A design safety analysis was developed using the installation information gathered and the preliminary system design.

Several MK-50 flares were ignited, using an "electric match" located in the flare pellet, to determine if the flare was self-ejecting when inadvertently ignited. In all cases, the flare pellet ejected instantaneously.

Preliminary Design

Two general dispenser assembly configurations were considered; internal (flush-mounted) and external (surface-mounted). In the flush-mounted assembly, the firing mechanism assembly is semi-permanently mounted in the dispenser housing (see Figures 1 and 2). The housing is flanged and mounted to reinforced aircraft skin sections.

In the surface mounting version, the firing mechanism assembly is semi-permanently attached to the baseplate (mounting plate) which is secured to the aircraft surface. The payload module is contained in an aerodynamically streamlined fairing. This configuration was not pursued past the preliminary stage because early in the program the dispenser assembly design was further defined by the project monitor, requiring a configuration which would interface with, and replace an AN/ALE-29A dispenser assembly. (This was done so that an OV-10 and an 0-2 aircraft, fitted with the AN/ALE-29A system, could be used to flight test the new system.)

The ability to fire the MK-50 Flare, (nomenclatured FLARE, DECOY, MK-50, MOD 0, INFRARED) was one of the dispensing mechanisms primary design requirements. In order to fire the MK-50, a striking energy of 30 ounce-inches or greater is required to discharge a percussion primer (Type M39A1).

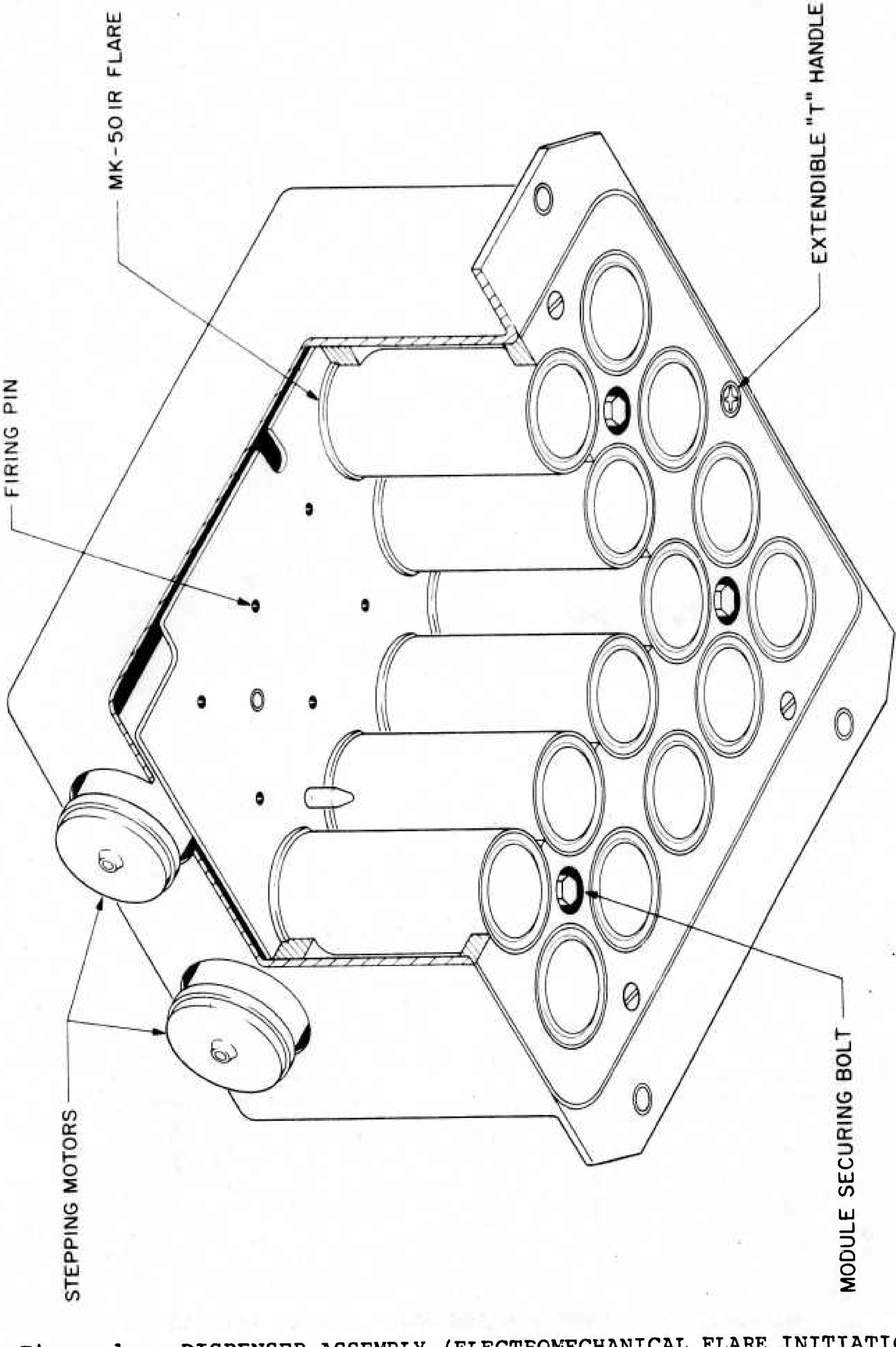

Figure 1 - DISPENSER ASSEMBLY (ELECTROMECHANICAL FLARE INITIATION)

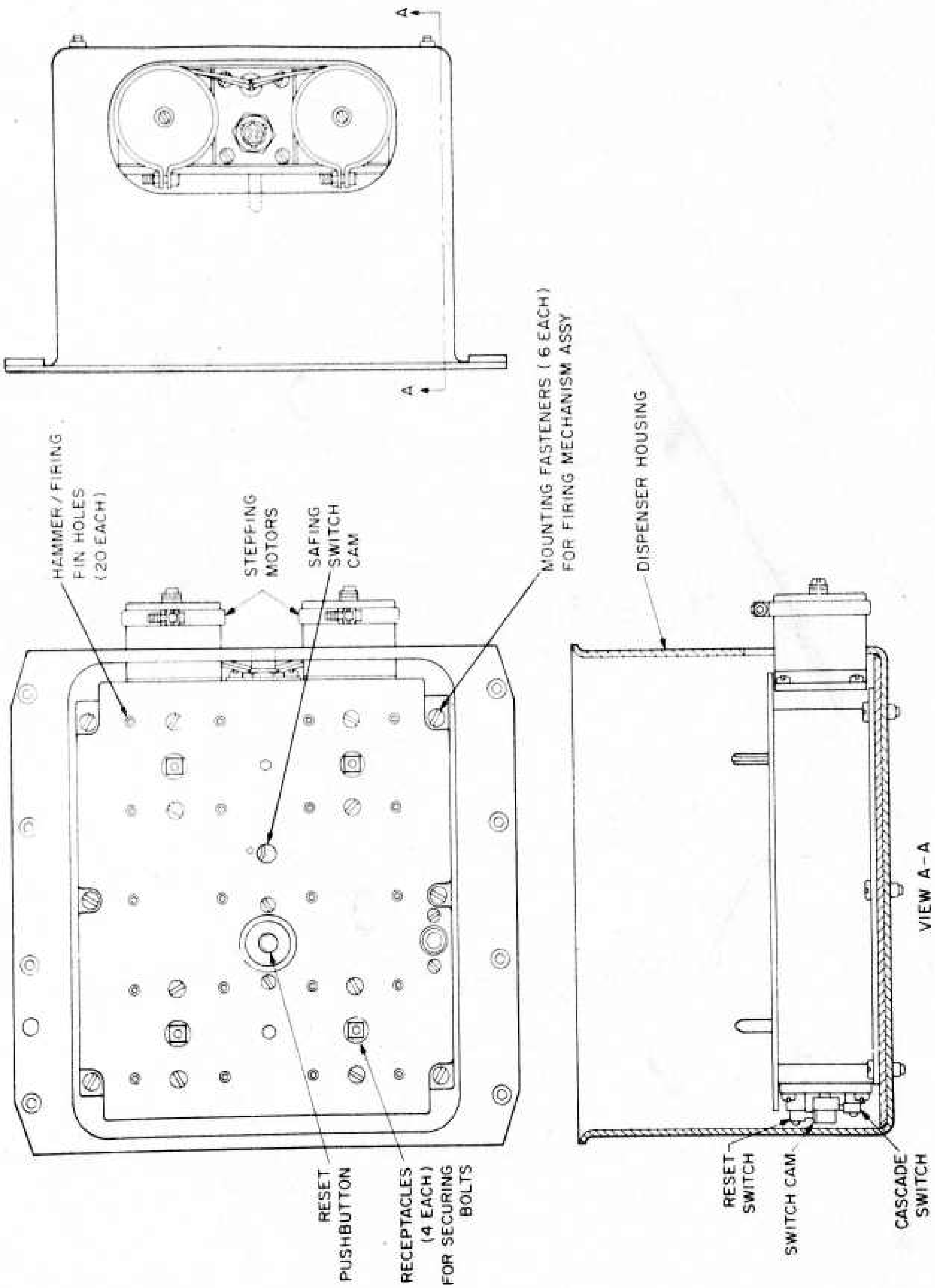

Figure 2 - DISPENSER ASSEMBLY (MODULE REMOVED)

A model of the firing mechanism was built to establish the requisite hammer/firing pin striking characteristics, verify the triggering function and determine the torque required for sear displacement (Figures 3 and 4). The model was also submitted to shock loading and vibration to insure proper function during and after required test conditions.

The firing mechanism function is shown in Figure 5. The hammer at the left of the sketch is cocked and restrained by a sear pin. The sear pin is prevented from moving by the sear which is springloaded in a downward position. The hammer is released when the sequencing shaft is stepped to the angular position where the shaft tooth engages the sear tooth, causing the sear to move upward. This allows the sear pin to engage the sear notch. The sear pin is moved into the sear notch by a force component produced by the hammer cone angle and the hammer spring force.

Cocking is accomplished by compressing the hammer spring with the hammer, moving it downward until the sear pin is moved into the path of the hammer by a force component produced by the sear notch angle and sear spring force. This firing mechanism was proven effective and reliable on several previously built Lundy chaff dispensing systems.

Two types of flare modules were considered during the preliminary design effort. Engineering models of each were built and evaluated. One type is fabricated primarily from machined aluminum and consists of a muzzle plate and a breech plate which are separated by "stand-off" rods. The other type is fabricated primarily from non-metallic materials and consists of a fire retardant polyurethane foam core bonded to, and sandwiched between, a muzzle plate and a breech plate made of a fiberglass phenolic laminate. All exposed foam surfaces are coated and sealed with polyurethane.

In the aluminum module, the flares are retained by nylon rings which are recessed in circumferential grooves in the muzzle plate. In the plastic module the flares are retained by the foam core. Both module designs include vibration-resistant, self-locking securing bolts.

The control/display unit was defined as a single chassis, cockpit mounted unit. It provides the control point for selection of IR flare ejection mode and allows the aircrew to operate the dispenser system. It also provides displays showing system operation and stores remaining update. (Figure 6).

Remote IR flare ejection command signals can be initiated through the control/display unit, by either a missile launch detector (AUTO) or a pilot's stick switch (MANUAL).

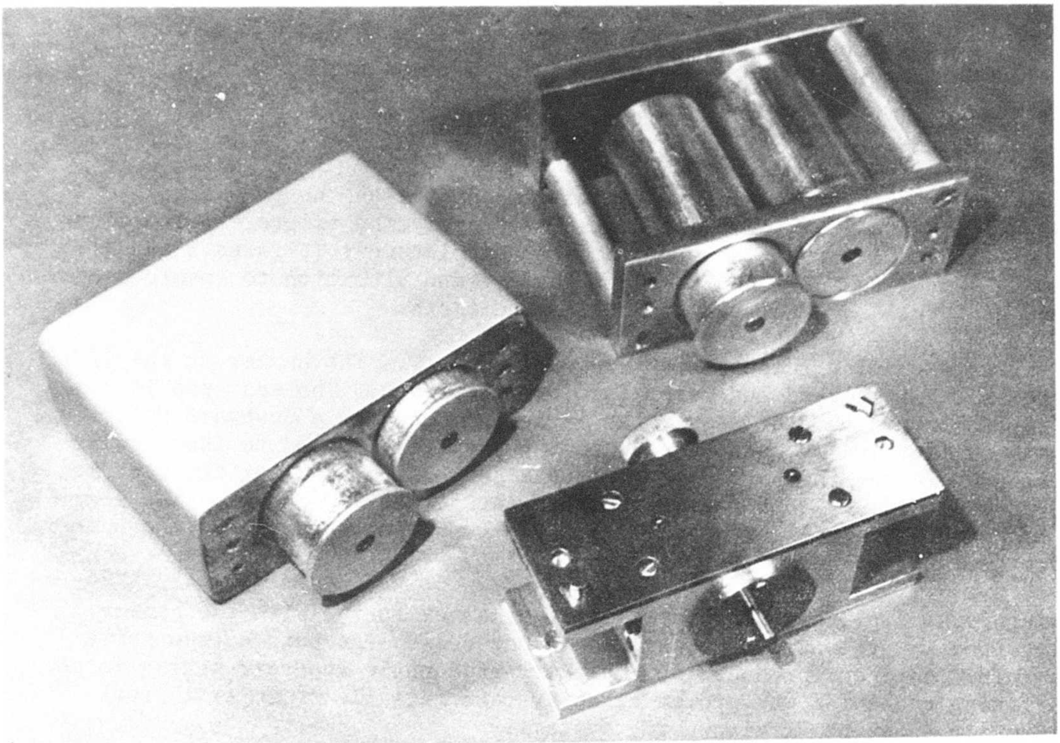

Figure 3 - ENGINEERING MODELS

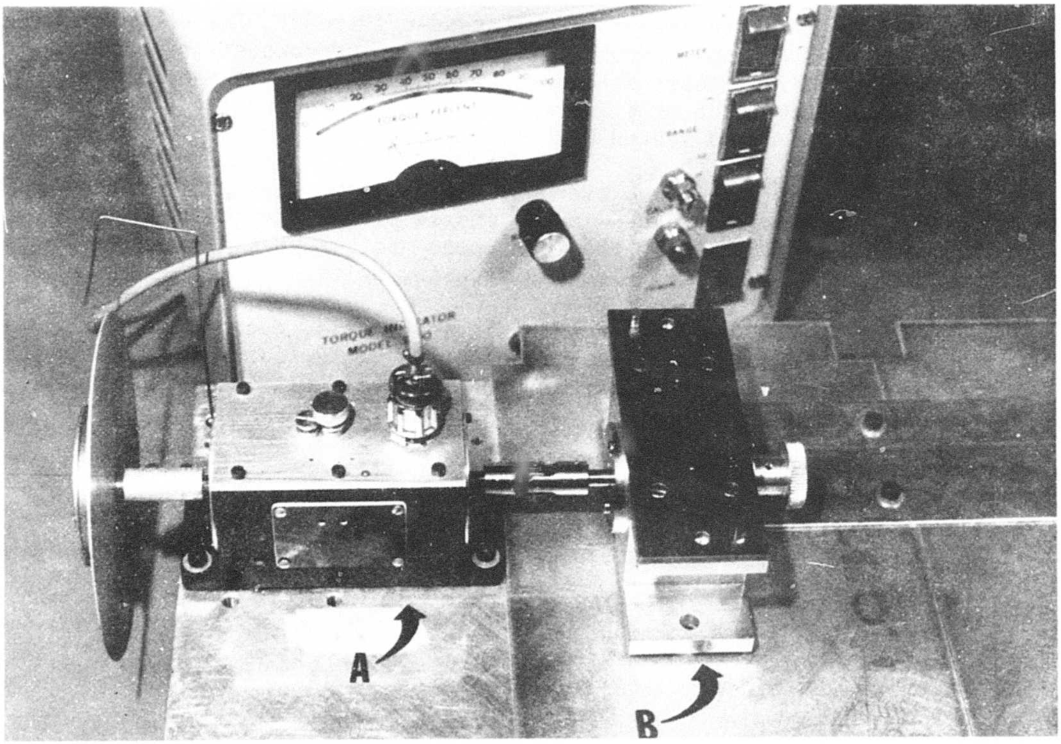

Figure 4 - MODEL TESTING

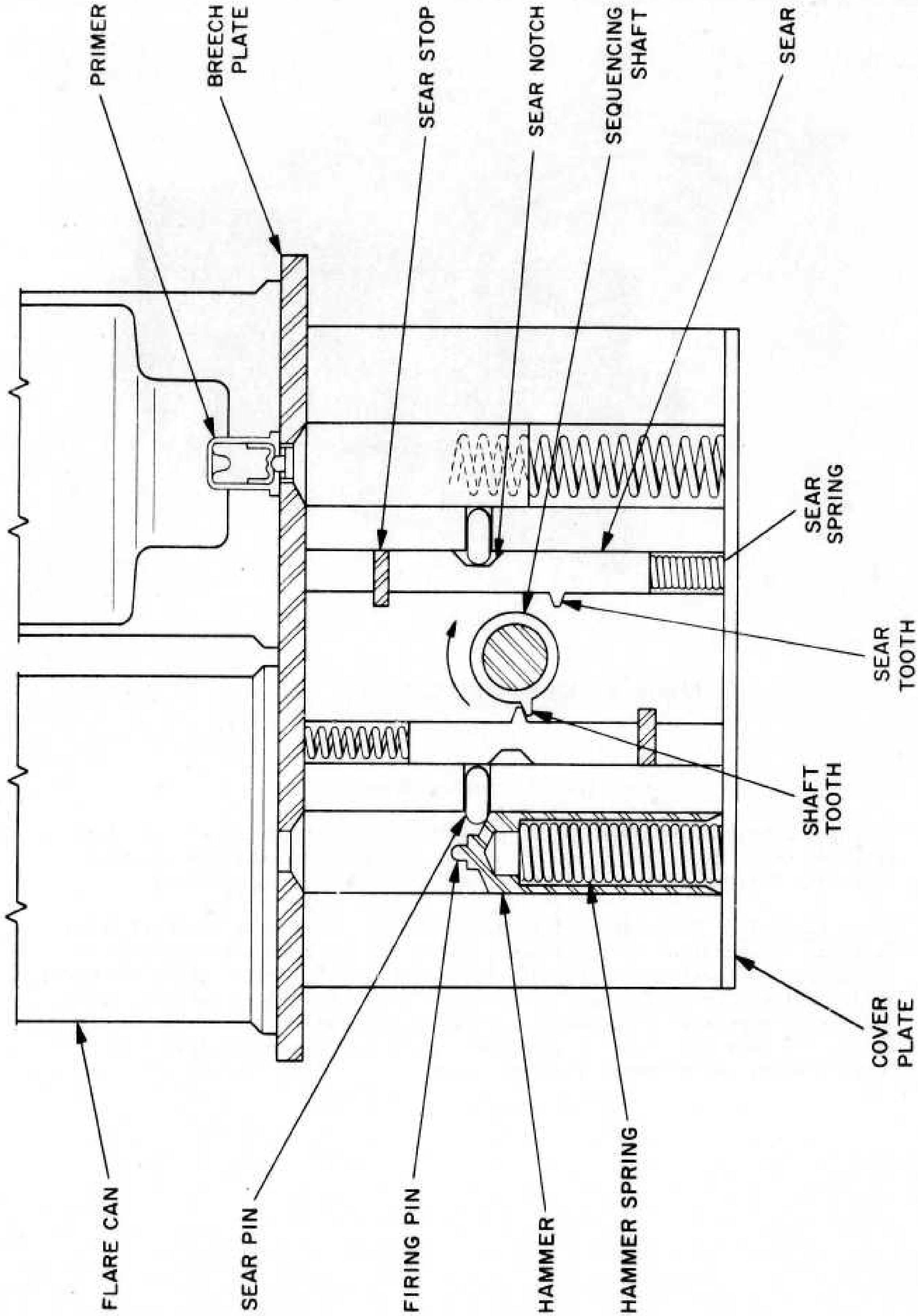

Figure 5 - FIRING MECHANISMS

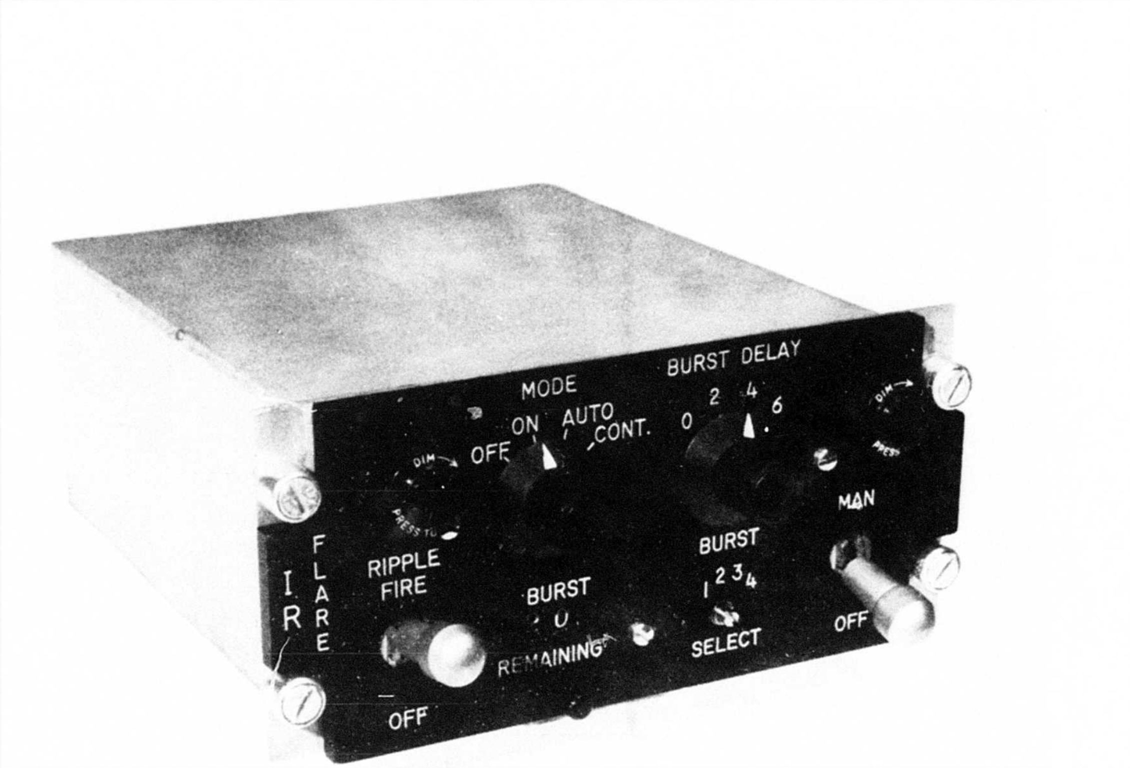

Figure 6 - CONTROL/DISPLAY UNIT

Installation/Location Study

During the initial 60 days of the program effort, the 0-1, 0-2 and OV-10 aircraft were investigated and inspected to determine suitable mounting locations for the dispenser assembly and the control/display unit.

OV-10 Aircraft - Aircraft tail number 67-14610, located at Hurlburt Field, Florida, was examined by Lundy personnel to define mounting positions on the OV-10. A location in the left tail boom, a few inches behind the wheel well opening (Figure 7), had been previously determined suitable by Kelly AFB, Texas personnel responsible for the configuration management of the OV-10. In this position the dispenser is mounted (openings downward) between boom, the external skin and floor.

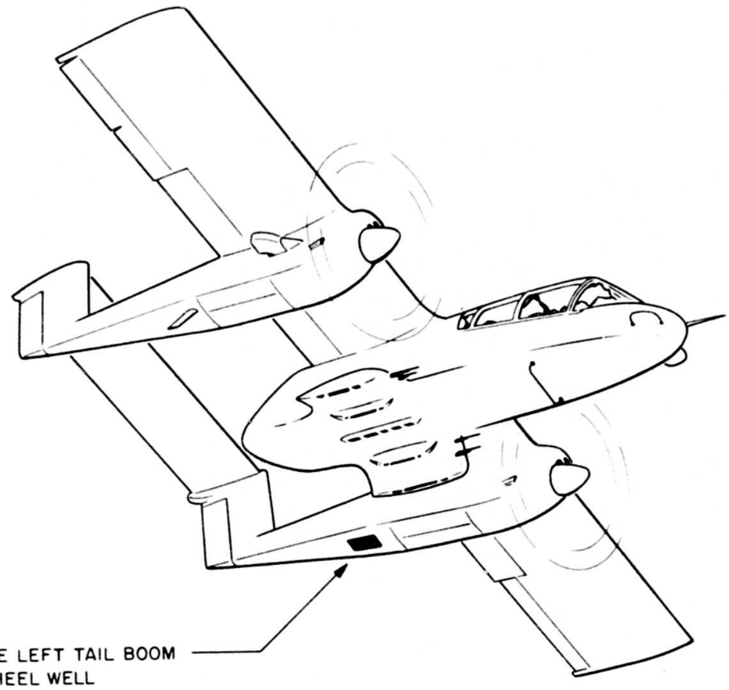

Figure 7 - OV-10 FLARE DISPENSER LOCATION

There were four locations for the control/display unit which requires a standard 3 by 5 inch opening; one at the pilot's position is located on the right hand instrument console, (arm-rest position), alongside the pilot's right arm.

The spaces at the observers position are directly in front of the observer and to his right, on the instrument panel.

The recommended mounting location was the right hand instrument console at the pilot's position, since the observer position is not occupied on every mission.

<u>0-2 Aircraft</u> - While at Hurlburt, Lundy personnel also examined 0-2, tail number 68-10849 to find candidate system mounting locations.

The cognizant configuration management people at Kelly AFB, Texas, suggested the mounting location for the flare dispenser on the 0-2 be directly beneath the co-pilot's seat, attached to the external skin and protruding slightly above the floor (Figure 8).

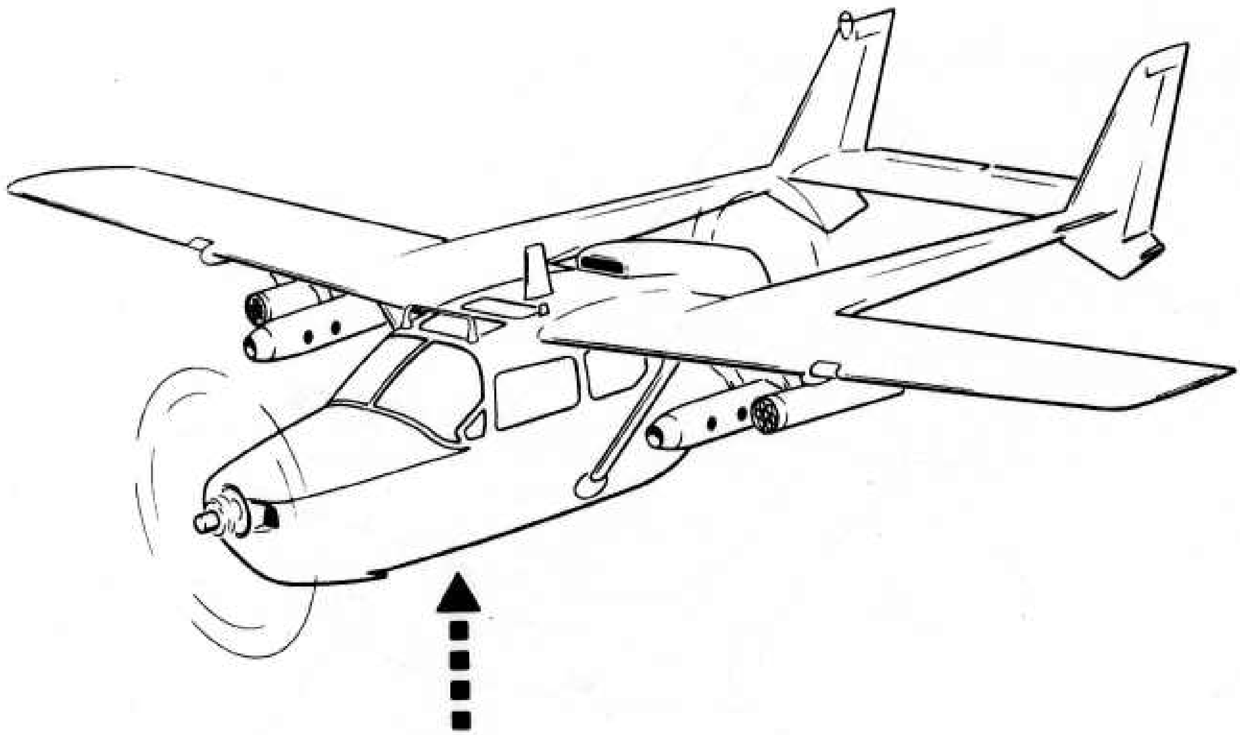

Figure 8 - O-2 DISPENSER LOCATION

Lundy's investigation of the aircraft revealed this to be the only available free space because of two engines on a relatively small airframe, the substructure is crowded with cables and control linkages and mountings for stores.

Two obvious locations were available in the cockpit for mounting the control display unit. One location, standard 3" x 5" size, is at the bottom of the center console. The other location is the space presently occupied by an ashtray on the instrument panel, in front of and to the right of the co-pilot. The center console is the preferred location as it would be difficult to operate the control from the left seat since the right seat may not always be occupied.

O-1 Aircraft - An O-1, located at Wright-Patterson AFB, Ohio, was examined to determine logical dispenser mounting locations. From a structural standpoint the aircraft is simple. It has a stressed skin monocoque construction, with few hidden compartments and a relatively uncluttered interior. There is a floor panel, extending only the length of the cockpit, with about four inches of space between this floor and the bottom of the fuselage.

There was no obvious or simple locations to mount the flare dispenser internally. The underside of the fuselage, at any position along its length, was unacceptable because control cables extend the full length of the fuselage just under the skin. Mounting the dispenser on either side of the cockpit was unacceptable because it would interfere with the pilot, observer, or equipment already located in these positions. Mounting the dispenser on the door side of the fuselage just aft of the cockpit area is possible except that skin and rib reinforcement would be required in that area to support the dispensing equipment. Also, the resultant weight of the reinforcement and the loaded dispenser at that location may have an unacceptable effect on aircraft control and stability because of the resultant rearward displacement of the aircraft center of gravity.

Discussions with Warner Robins AFB personnel indicated that all series designations of the 0-1 are currently flying at weights in excess of their recommended gross weight and with a rearward center of gravity displacement which allegedly prompts pilots to term the aircraft a "tail dragger".

Any dispenser mounting on the rear fuselage which aggravates this situation would appear to be unacceptable.

Though weight problems will still exist, control and stability problems in the pitch plane can be avoided by mounting the dispenser on the pitch axis center of pressure which is typically along a wing span line at a position 25% of the wing chord back from the leading edge. Fuel tanks in the wing occupy the inboard portion of this line. Outboard of the tanks the wing is not deep enough to accept a dispenser and an outboard dispenser would affect roll control and stability.

Roll effects and pitch effects can be avoided by mounting the dispenser on the effective integrated center of pressure, a point on the vertical yaw axis which is at the intersection of the fuselage longitudinal axis and pitch axis. This point is under the pilots seat (see Figure 9). As stated previously, this fuselage position is occupied by control linkages which would make an internally mounted configuration impractical.

Figure 9 - 0-1 DISPENSER LOCATION

A recommended alternative to internal mounting was to mount the dispenser external to the aircraft at the center of pressure. The fuselage underside area between the landing gear is essentially flat. Underneath the skin are two structural beams, spaced about 8 inches apart, extending the cockpit length. These two members provide attachment points for a dispenser mounting.

Two mounting space possibilities for the control display unit were identified. One location is presently occupied by an ashtray on the sidewall to the right of the instrument panel. The other location is at the bottom edge of the instrument panel.

Safety Analysis

A preliminary safety analysis was prepared by analyzing various abnormal conditions, postulating possible malfunctions under those conditions, and determining the resultant effects on personnel and equipment.

The analyses considered hazards resulting from:

a) Electromagnetically induced currents
b) Electrostatic discharge
c) Short circuit or cross circuit
d) Mechanical failure
e) Operator error
f) Small arms fire
g) Self-ignition
h) Aircraft fire
i) Mishandling of flares/flare modules

The flare dispensing system has several safing features, some of which are inherent in the design and others which are specific to safe operation. The gun mechanism is single-action which requires each hammer to be manually "cocked" so a store cannot be fired without prior cocking. Removing the module interrupts the firing train, thus when the module is removed for loading and servicing, it is totally safed.

Percussion initiation also provides an inherent safety factor which is non-existent in electrically initiated pyrotechnics. The hammer and anvil within a percussion primer are designed in such a manner that the firing pin must strike the proper place with just the right combination of velocity/mass characteristics to achieve ignition. Thus the unit is immune to accidental initiation.

Both a safing switch and the system power switch interrupt the electrical power required for system operation. In addition, the system is mechanically safed by sear locking safing bars which interfere with the sear movement required to fire a flare. The safing bars are held in the safe position by the crew safing pin. The dispenser is armed both electrically and mechanically when the crew safing pin is removed.

Table I lists the preliminary safety analysis results. The chart headings are self-explanatory to some extent. "ERROR OR MALFUNCTION" is whatever can be rationalized. "EFFECTS" are fire, smoke, radiation, blast, fragmentation or any other descriptive terms which connote the resultant event. "CRITICAL EFFECT" means a catastrophy in terms of disabling aircraft or personnel. "CAUSES" identifies the source or originating agent of the error, if one exists, other than random probability. "CORRECTIVE ACTION" defines what is necessary to modify error occurrence, reduce the error rate, or eliminate the error entirely.

Ground Operation

Ground operation consists of a series of check outs to insure the system is working properly prior to loading and a loading procedure.

The dispensing system function is verified using the following check out procedure:

TABLE I

PRELIMINARY SAFETY ANALYSIS

Error, Malfunction or Failure	Effects	Critical Effects	Causes	Corrective Action
Safety Pin Omitted	Flare Ignition will occur if Stepping Motor receives Electrical Pulse	Possible Injury to Personnel	Ground Crew Error	Reprimand and Additional Training
Safety Pin Left In	Dispensing Prohibited	None	Ground Crew Error	Reprimand and Additional Training
Loaded Dispenser Dropped Furing Removal or Installation	No Flare Ignition (Mechanism is Shock Insensitive.) Housing Bent or Dented	None	Ground Crew Negligence	Reprimand and Additional Training
Module Installed with One Fastener	In-flight Vibration Causes Module Fallout. Flare Dispensing Voided.	None	Ground Crew Error	Reprimand and Additional Training
Short Circuit in Stepping Motor	Circuit Breaker Will Open	None	Life Cycle Failure	Use Better Stepping Motor
Internal Electrical Short Between Reset Power & Stepper Motor & Arm Solenoid	Flare Ignition Will Occur Once and Motor Will Overheat	Possible Injury	Electrical Wire Short	Careful Design & Production Technique & Addition of Thermal Protector
Hammer Spring Break	Flare Ignition Possibly Prohibited	None	Life Cycle Fatigue	Use Better Spring
Sear Spring Break	Inadvertent Flare Ignition	Possible Injury	Life Cycle Fatigue	Use Better Spring
Sear Tooth Break	Flare Ignition Prohibited	None	Fatigue Failure	Use Better Sear Shaft
Sear Pin Break	Inadvertent Flare Ignition	Possible Injury	Fatigue Failure	Use Stronger Material
Stepping Motor Mechanical Jamb	Dispensing Prohibited	None	Metal Failure	Use Better Motor
Ground Fire or Shrapnel Strikes Flare	Flare Ignition & Ejection Will Occur	Possible Injury	Combat Conditions	None Available, Except Avoid Hazardous Condition

a) Firing Mechanism Assembly

With the flare module removed, aircraft power ON, and system power ON, the dispenser is reset to the READY position by depressing and releasing the reset button until clicking stops (Figure 10).

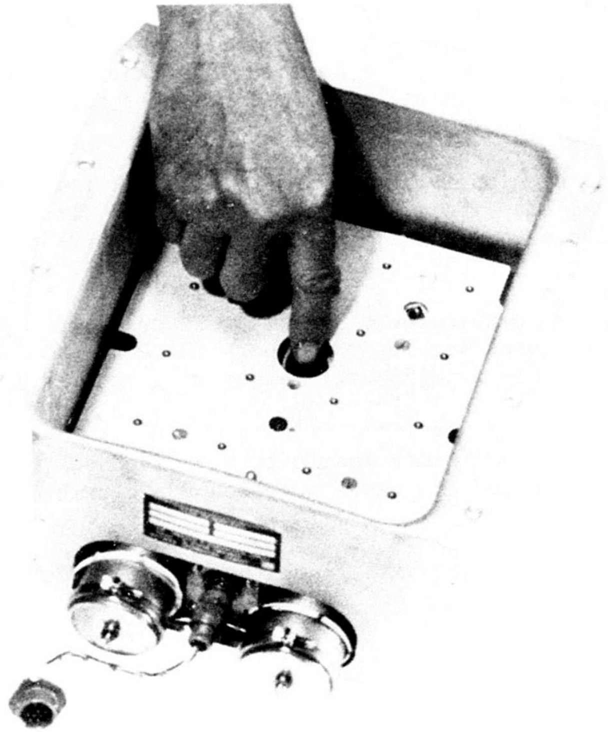

Figure 10 - ACTUATING RESET BUTTON

The hammers are cocked using the modified screwdriver cocking tool. As the hammers are reset, increasing resistance can be felt as the hammer spring is compressed. When fully depressed, a positive, audible click can be heard when the sear pin engages the hammer. A lack of resistance indicates a weak or broken hammer spring and excessive resistance indicates a binding condition. Failure of the sear to engage the hammer in a positive fashion indicates faulty sear operation.

Following the cocking operation, the system can be operated through a dispense cycle using the switches on the cockpit control to insure proper function.

b) Flare Module and Safing Mechanism

To check the mechanical safing mechanism an empty flare module with safing pin in place is installed in the dispenser. System power is applied and the system is operated using the cockpit control switches. There should be no activity at the dispenser with the safing pin installed. With the safing pin out, the system should operate normally.

c) Cockpit Control

In order to verify proper control unit operation, several dispense cycles at various settings are made with the dispenser empty. It is not necessary to cock the dispenser for the control unit functional checkout. Operation of the stepping motors can be heard and indicates that signal pulses are being delivered to the dispenser.

Loading - The loading operation begins with system power off and the crew safety pin installed. The flare module is removed from the housing by releasing the two extendible "T" handles and then removing the four securing bolts.

Expended flares are removed by a slight pressure (1 to 2 pounds) at the muzzle end. New flares are loaded through the module breech plate. The flares are retained by a peripheral keeper ring located in the muzzle plate.

Prior to installing the loaded module in the dispenser housing the stepping motors must be reset and the hammers cocked as described in paragraph 3.3.1.

The flare module should be installed with the crew safety pin in place. The module must be guided into the dispenser and held in position while the securing bolts are fastened.

To summarize the loading operation:

a) Turn System power off
b) Insert crew safety pin in flare module
c) Remove empty flare module
d) Reset stepping motors
e) Cock hammers
f) Install loaded flare module
g) Remove crew safety pin prior to flight

Equipment Description

Dispenser Assembly - The dispenser assembly consists of a dispenser housing, a flare module and a firing mechanism assembly.

Dispenser Housing - The dispenser housing contains and supports the dispenser assembly components. It is a drawn aluminum alloy shell with a reinforced

mounting flange. The housing is 9.5 inches long, 8.0 inches wide and 6.2 inches deep, excluding the mounting flange. The housing weighs approximately 4.0 pounds.

A modified AN/ALE-29A dispenser housing was used with the brassboard dispenser assembly. (The ALE-29A housing is only slightly larger than the smallest housing which could be designed to contain the dispenser assembly). The modification entails installing anchors and fasteners in the housing base to retain the firing mechanism assembly, and machining two holes in one end panel to provide clearance for the stepping motors. (See Figure 11).

Flare Module - The flare module consists of a 3/8 inch thick face plate and 1/2 inch thick breech plate joined as a unit by 3 inch long standoffs. The face and breech plates are aluminum alloy with bored holes to accept and properly interface with the flare can. The standoffs are 1/2 inch diameter aluminum alloy stock and joined to the face and breech plate using flush screws to form an inseparable assembly. (See Figure 12).

The module mounting bolts are of the vibration resistant, self-locking type and are held captive in the module. The flare module is removed during ground operations for flare unloading/loading and to provide access to the firing mechanism assembly. It is 7.4 inches wide, 9.1 inches long, 3.9 inches deep and weighs 4.1 pounds.

A crew safety pin is mounted integrally with the module. The pin is slightly grooved to allow for retention. The pin is inserted and removed through an access hole provided in the mounting flange.

Firing Mechanism Assembly - The firing mechanism assembly is comprised of two similar sub-assemblies positioned between a breech plate and a baseplate. These sub-assemblies hold all parts necessary to fire 10 flares. These parts are contained in a mechanical aluminum frame and includes a stepping motor, a sequencing shaft, ten firing trains and a sear-locking safing device. There are two safing bars in each sub-assembly. These bars are parallel to the sequencing shaft and are positioned so as to interfere with sear movement when in a forward position and allow free movement when retracted. The safing bars are actuated through mechanical linkages by a spring-return cam. (Figures 13, 14, 15, 16, 17 and 18).

The firing mechanism assembly is not removed during normal ground operations but can be easily removed for servicing if necessary. It is 2.1 inches thick, 6.5 inches wide, 10.5 inches long and weighs approximately 9.0 pounds.

Control/Display Unit - The control display unit provides a control point for selecting the IR flare ejection mode and allows the aircrew to operate the dispenser system. It also provides displays showing system operation and stores remaining update.

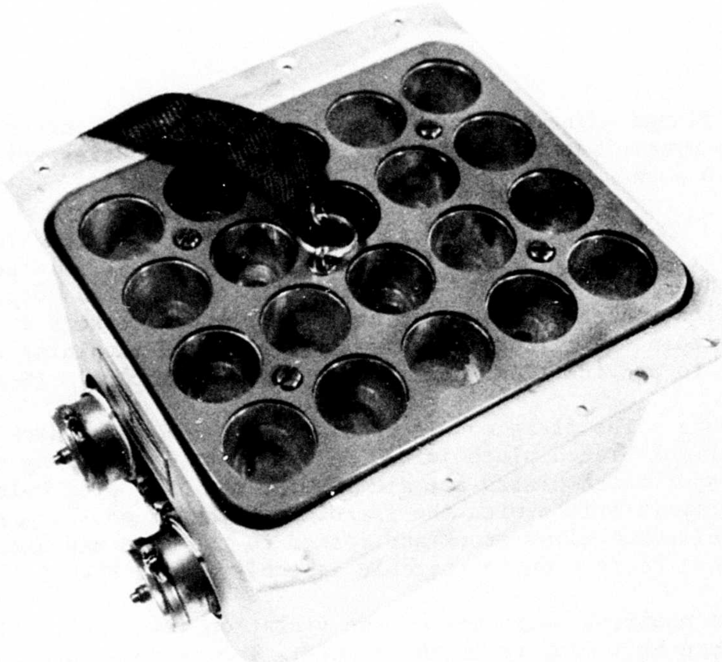

Figure 11 - DISPENSER ASSEMBLY IR FLARE DISPENSING SYSTEM

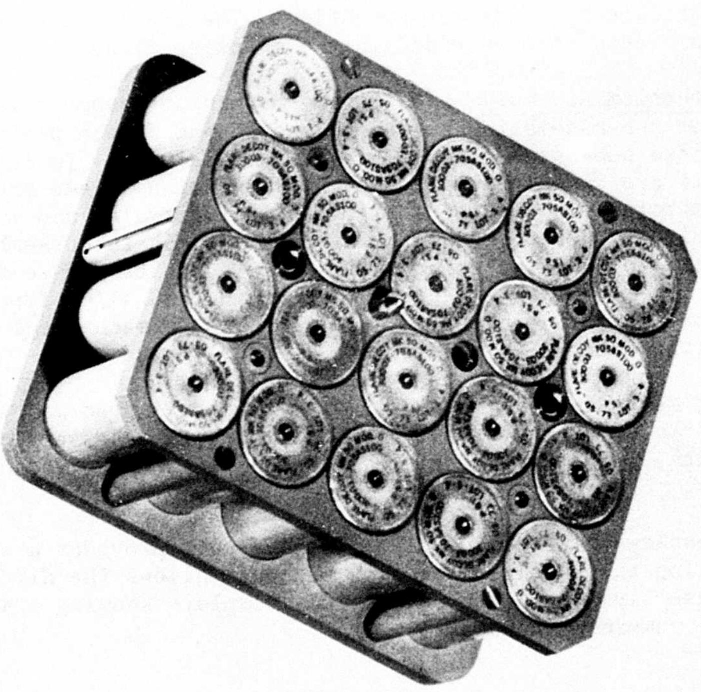

Figure 12 - FLARE MODULE, (ALUMINUM)

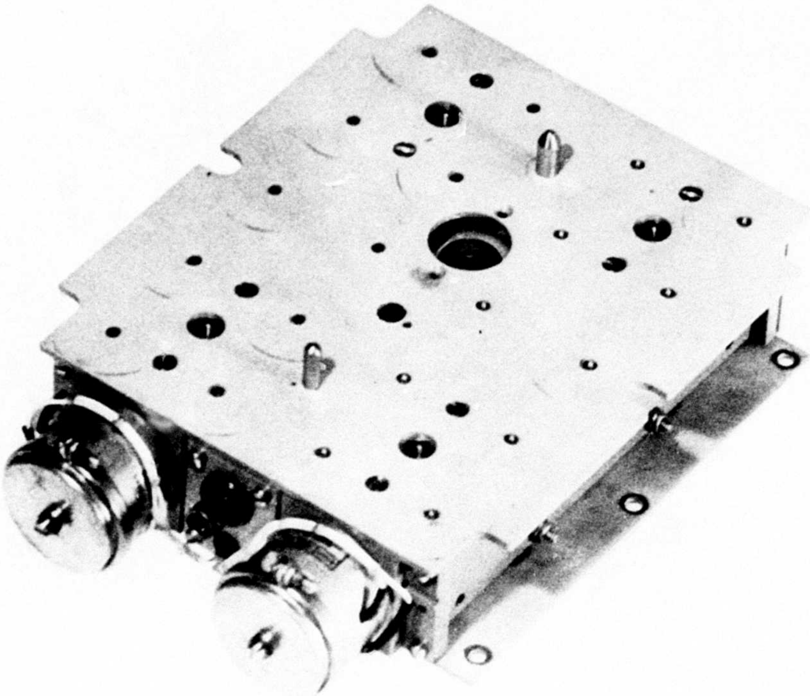

Figure 13 - FIRING MECHANISM ASSEMBLY

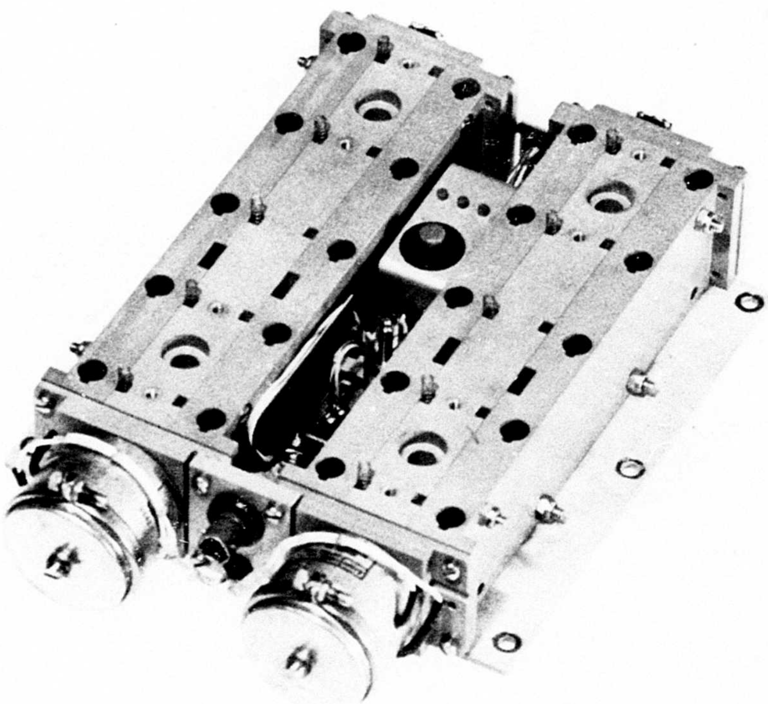

Figure 14 - FIRING MECHANISM ASSEMBLY (BREECH PLATE REMOVED)

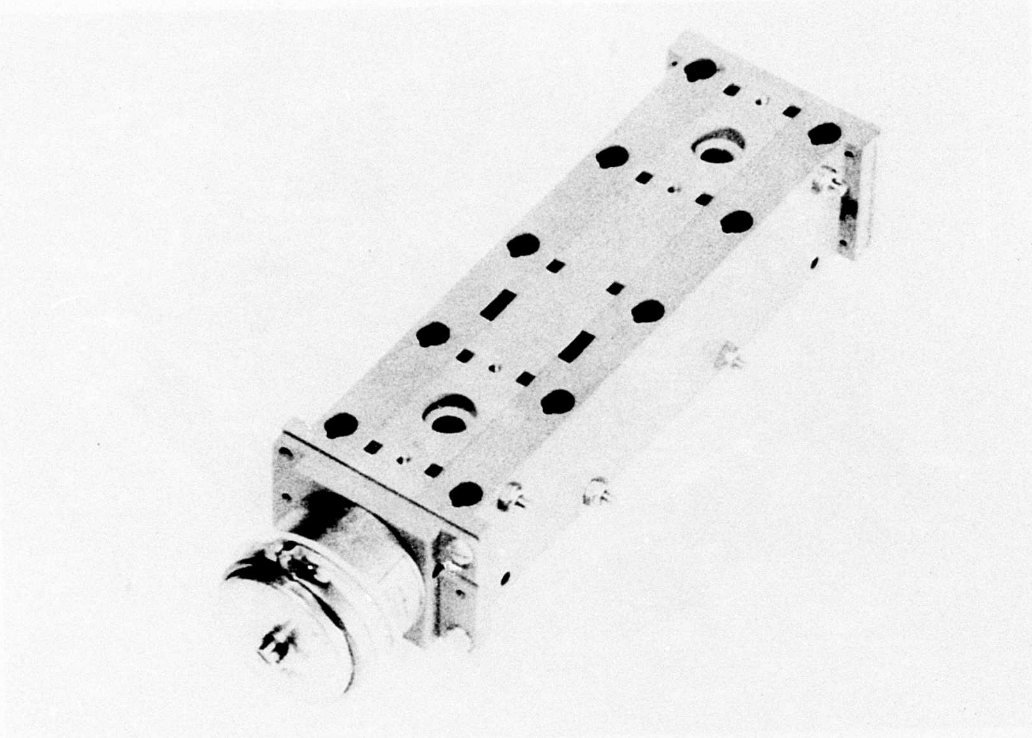

Figure 15 - 10 UNIT SUB-ASSEMBLY

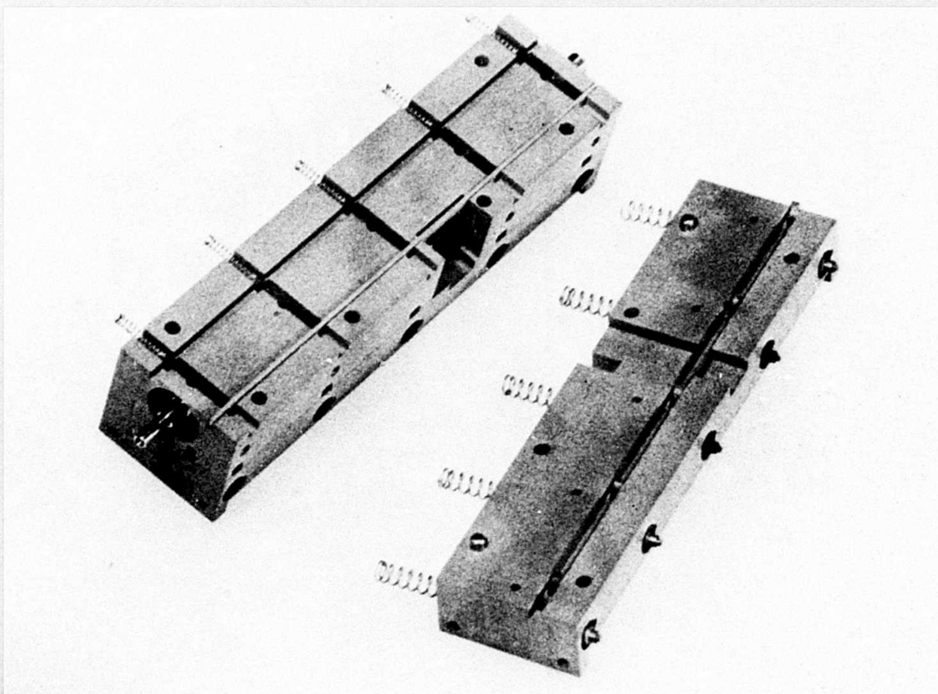

Figure 16 - SUB-ASSEMBLY DETAIL

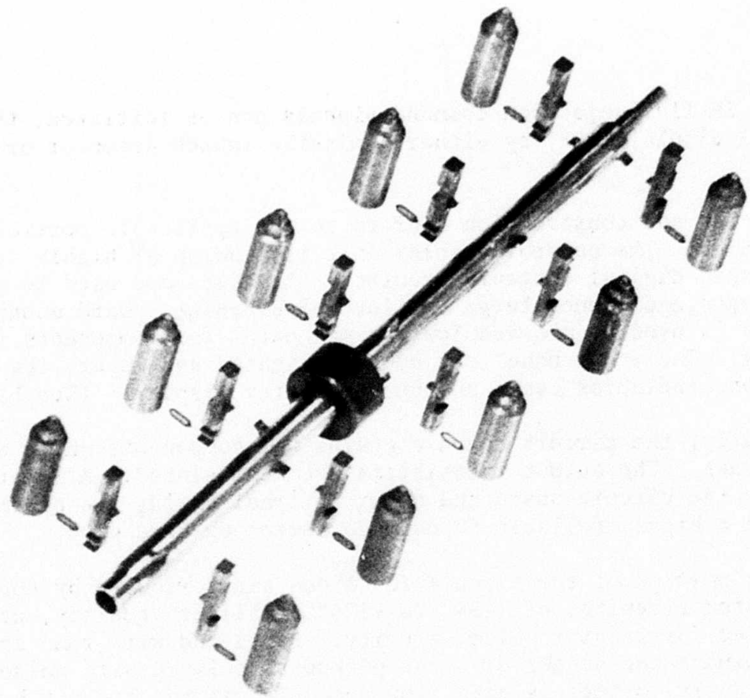

Figure 17 - FIRING TRAIN COMPONENTS

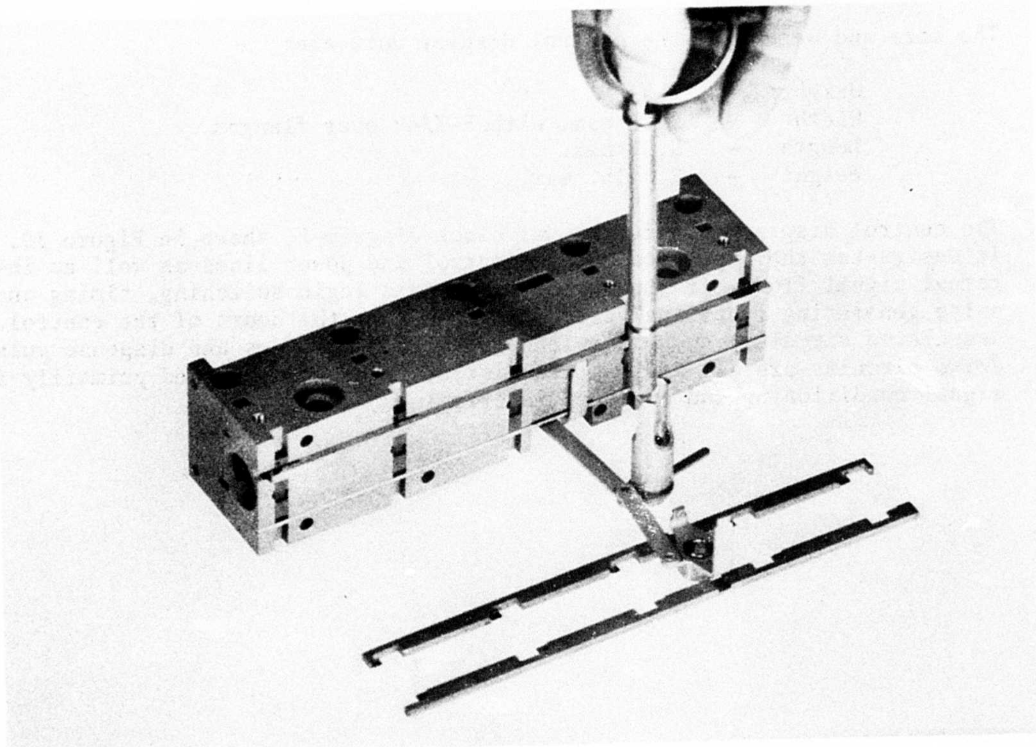

Figure 18 - MECHANICAL SAFING SYSTEM

Remote IR flare ejection command signals can be initiated, through the control display unit, by either a missile launch detector or a pilot's switch.

Its design and construction conform to the applicable portions of MIL-E-5400. The control display unit is made up of highly reliable, micrologic digital control circuitry. Brackets are used to support heavier components and reduce large catilevered overhang. Hard mounting to the chassis is used to provide low thermal paths for components requiring heat sinking. The front panel can be edge lighted and mounts the control switches, indicator lamps and burst counter display. (See Figure 6).

Internally, the circuit board contains all components which do not require heat sinks. The output transistors are heat sinked. All interconnections between the circuit board and other internal wiring are accomplished through a highly reliable PC card connector or hard wire.

A major portion of the circuit functions are performed by compatible integrated circuits, of (-54° to +125°C) military quality, utilizing 10 VDC power for greater noise immunity. Parts and wire runs are laid out to eliminate the danger of stray pickup associated with noise. Logic power supply voltage is capacitor decoupled at the circuit board as well as at the power source. The interface connector protrudes from the back of the assembly to provide a convenient connection with the interconnection cable.

The size and weight of the control display unit are:

Height	-	2-5/8"
Width	-	5.0" max. with 5-3/4" over flanges
Length	-	5.0" max.
Weight	-	2.0 lb. max.

The control display unit functional block diagram is shown in Figure 19. It designates the input and output control and power lines as well as internal signal flow. It shows microelectronic logic switching, timing and pulse generating functional circuits which form the heart of the control. Associated circuitry such as voltage regulator, buffers and dispense pulse drive circuits are all solid state discrete elements designed primarily for signal conditioning and/or power interfacing.

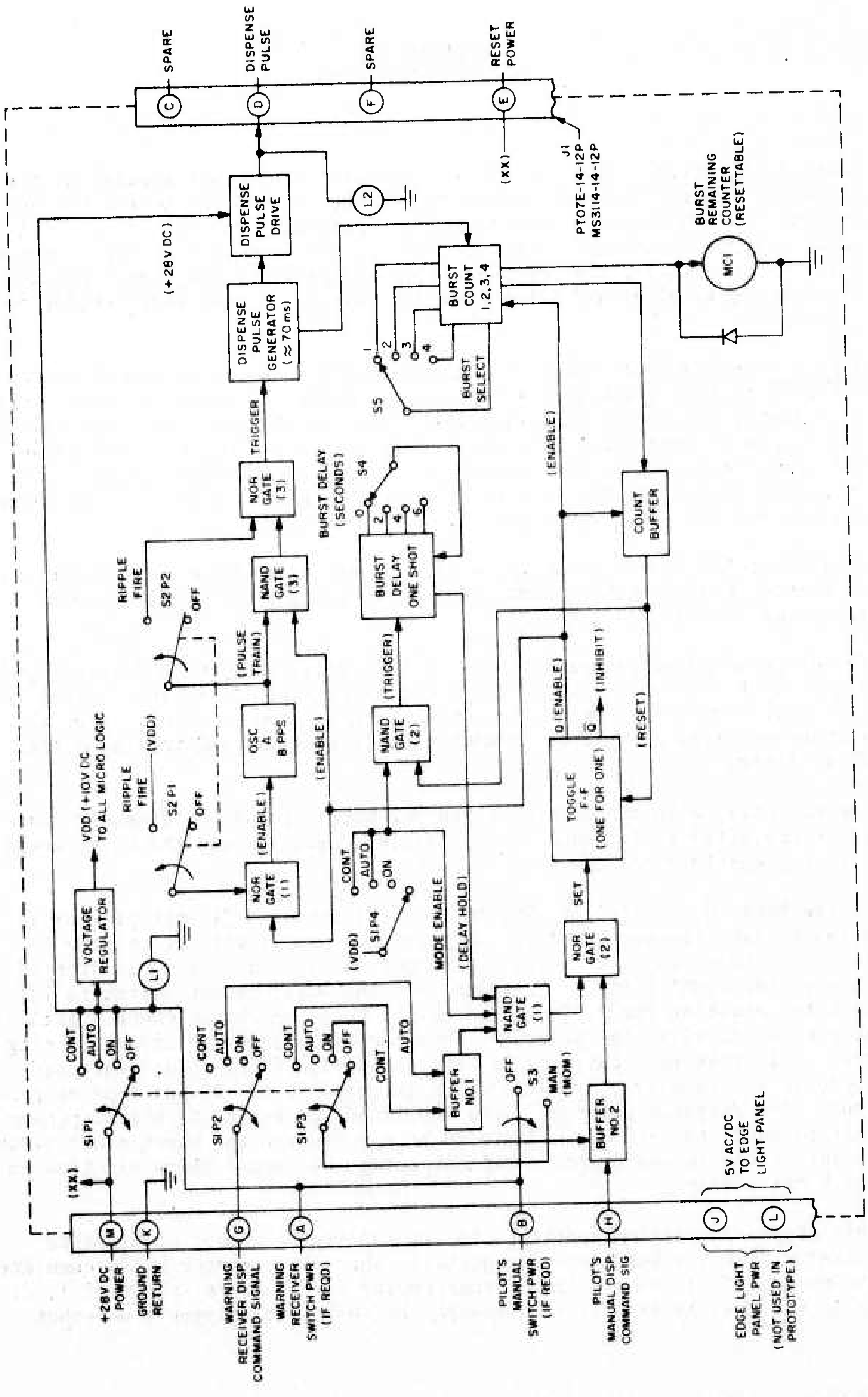

Figure 19 - CONTROL DISPLAY UNIT FUNCTIONAL BLOCK DIAGRAM

Section III
EQUIPMENT OPERATION

Power Application - With the +28 VDC (ON position) power applied to the dispenser system, the mode select switch applies +28 VDC to the voltage regulator which, in turn, provides VDC regulated power to all internal logic control circuitry. The switched +28 VDC is routed to the dispense pulse drive circuit, the power-on lamp, and provides the signal voltage to the warning receiver and pilot's manual switch, if required. (Refer to Figure 20).

Manual Dispense Mode - When the MAN/OFF control switch is placed in the manual position, the signal is applied to buffer #2 which, in turn, triggers (sets) the toggle flip-flop (F-F) through NOR gate (2). The one-for-one toggle circuit makes it necessary to remove the input signal prior to its reapplication. As the toggle F-F is set, the Q output changes state to enable oscillator "A" (through NOR gate (1)), NAND gate (3), the count buffer, and the burst count circuit.

Oscillator "A" starts producing a pulse train at 8 pulses per second which is routed through enabled NAND gate (3) to trigger the dispense pulse generator through NOR gate (3).

The dispense pulse generator produces a 70 millisecond wide dispense pulse signal to the drive circuit. The drive circuit amplifies this signal to the level required to drive the dispenser unit stepper motor. When the stepper motor is energized, it mechanically triggers and initiates the first flare.

Concurrently, with the dispenser stepper motor operation, dispense lamp L2 is energized to indicate the dispensing operation and the burst count circuit registers one count.

If the Burst Select switch, S5, is in the 1 position (1 unit per burst) a count signal is generated to energize the burst remaining counter to count one burst in a retrogressing manner. Also the program is stopped through the count buffer. Assuming that the burst select switch is in a selected position for 2, 3 or 4 units per burst, no burst count signal will be present to alter the program. Thus the oscillator "A" circuit, being previously enabled, continues to time out at the 8 per second rate and produces a second trigger pulse which is gated to the dispense pulse generator. The dispense pulse is again amplified and routed to the dispenser unit to cause the second IR flare to be ejected and the burst count circuit registers the second count. This completes the second flare ejection in the burst series.

This dispensing action continues to accumulate the number of dispense pulses within the burst count register. When the register has accumulated the number of dispense pulses corresponding to the burse select of 1, 2, 3 or 4, a signal is transferred through the switch to trigger a one-shot

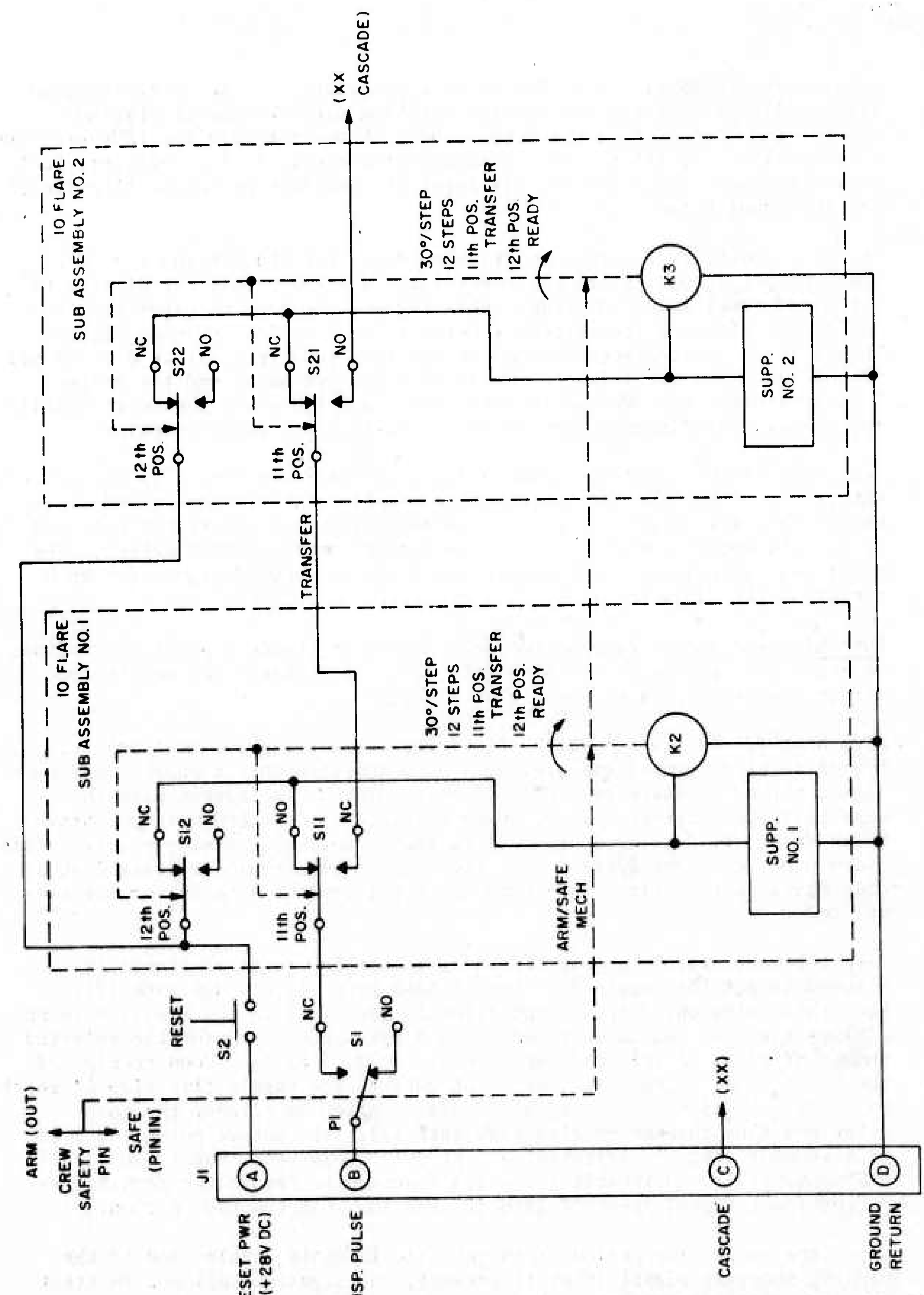

Figure 20 - IR FLARE DISPENSER ELECTRICAL SCHEMATIC

multivibrator (ISMV). The ISMV in turn generates a 30 to 40 millisecond drive pulse to energize the reverse counting electromagnetic display counter thus registering one burst count. Simultaneously the ISMV provides a reset signal to (1) return the accumulated count, in the register, back to a zero count condition and (2) reset the one-for-one toggle flip-flop via the count buffer.

Thus the burst count signal resets the toggle F-F via the count buffer. The Q output changes state and removes the control enable signal from all circuits. Oscillator "A" stops operating and the various gates and count buffer are disabled (inhibited) and the flare ejection sequence ceases. Thus a flare burst dispense sequence has been completed, at an 8 units per second rate, for the selected number of units per burst and the status display counter has subtract counted one count and shows the burst quality remaining. The dispense lamp flashes once for each dispense pulse.

Note that if the above described burst sequence is initiated by the pilot's remote manual switch, the operation is identical to that described above except that the external signal is buffered and then enters NOR gate (2) to set the toggle F-F, by-passing the control panel OFF/MAN switch. The pilot must also remove and reapply the dispense command signal for each repeat of the flare burst dispense sequence.

Auto Dispense Mode - Placing the mode switch in the AUTO position provides an entry into buffer #1 and NAND gate (1). This allows the warning receiver command signal to enter when it arrives.

Also NAND (2) is enabled which allows the burst delay one-shot multivibrator to be triggered and provide a hold function when a burst count signal appears. These two added circuits provide the system with the capability to dispense a flare burst sequence as selected with an inter-burst delay (0, 2, 4 or 6 seconds) to reduce possible warning receiver false alarm problems. The operation of the functional circuits to establish a dispense sequence, fire the flares and count are the same as for the manual mode.

With the mode switch in AUTO the buffered warning receiver signal is allowed to set the toggle F-F through NAND gate (1) and NOR gate (2). From this point on, dispense operation is identical to the manual mode and a flare ejection sequence is made at a 8 per second rate for the selected number of units as selected for a burst (1, 2, 3 or 4). Upon receipt of the burst count signal, via the count buffer, the toggle flip-flop is reset as usual. The same reset signal is also applied to trigger the burst delay one shot through enabled NAND gate (2). The output pulse (0, 2, 4 or 6 seconds long, as selected) of the burst delay one shot is applied to NAND gate (1) as an inhabit (or hold) function to remove the warning receiver input signal from NOR gate (2) for the selected time period.

After the delay time period, NAND gate (1) is again enabled and if the warning receiver signal is still present, the signal is allowed to start the next flare dispensing cycle.

The zero (0) burst delay time is set for approximately 50 milliseconds to allow completion of a prior dispense cycle before allowing a re-initiation of the next cycle.

Continuous Fire - The continuous firing mode is identical to the auto mode except that it is initiated manually by placing the MAN/OFF switch in the MAN position. Initiate signal entry is made through buffer #1. When the MAN/OFF switch is returned to the OFF position, the dispense sequence is ended with the cycle completion.

Ripple Fire - With the mode switch in the ON, AUTO, or CONT position and the RIPPLE FIRE switch is activated, Oscillator "A" is enabled through NOR gate (1) and its output pulse train is routed to trigger the dispense pulse generator through NOR gate (3), bypassing burst controlled NAND gate (3). The effect is an overriding dispense pulse train at 8 pulses per second (ripple fire rate), which produces flare ejection continuously until the ripple fire switch is returned to the OFF position. During the ripple fire the burst count will function to produce one burst count signal for each group of flare units ejected as selected (1, 2, 3 or 4). The magnetic counter on the control/display will respond to show bursts remaining. The ripple fire mode can be readily used as a flare jettison technique (see Figure 21).

Mode Priority - The priority given to the available dispensing modes are given below in descending order:

RIPPLE FIRE
PILOT'S MANUAL AND/OR OBSERVERS MANUAL
AUTO (WARNING RECEIVER) AND/OR CONTINUOUS MANUAL

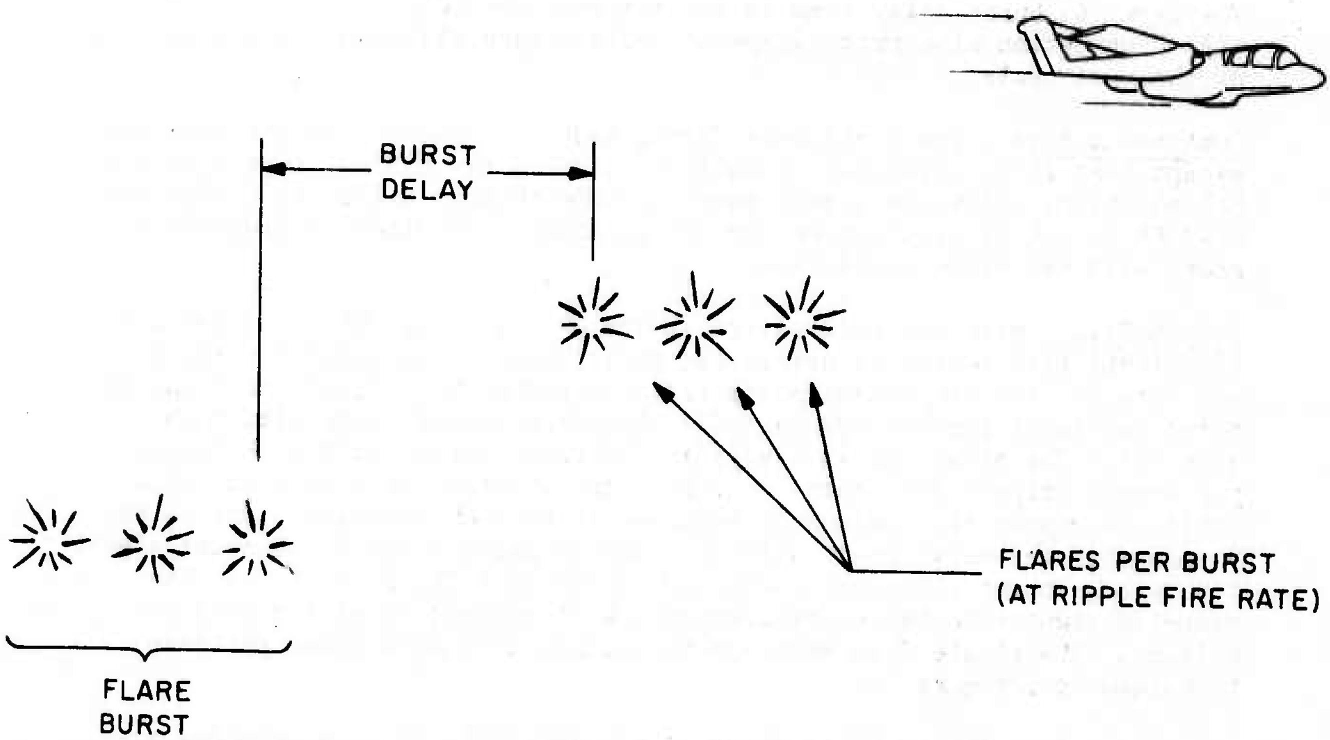

Figure 21 - FLARE SEQUENCE

Section IV
SYSTEM INSTALLATION

The installation sequence described applies only to aircraft modified to carry the AN/ALE-29A Countermeasures Chaff Dispensing System and further modified to provide adequate clearance for the stepping motor assemblies. The control unit can be installed in any standard 5-3/4" wide equipment rack having a 2-5/8" available height or in a custom fabricated mounting.

To install the dispensing system the existing AN/ALE-29A dispenser housing is removed by removing eight (8) 10-32 screws located on the housing flanges. These same screws are used to install the flare dispenser housing. As the ALE-29A housing is withdrawn from the aircraft, it is disconnected from the aircraft wiring at the connector.

The flare module and firing mechanism assembly must be removed from the dispenser housing prior to installation. The housing is installed and secured in the same manner as the ALE-29A housing. The torquing range for

the flange screws is 12-15 in./lbs. During insertion of the housing, the aircraft cable should be pulled through the cutout in the housing end wall.

The firing mechanism assembly is installed in the housing by 1) mating the connector on the assembly with the connector on the aircraft cable, 2) rotating the assembly into position with the stepping motors extending through the cutout in the housing and 3) securing the assembly to the housing with six (6) 10-32 screws. The torquing range for the screws is 12-15 in./lbs.

The flare module is installed in the housing and secured with four (4) 1/4-20 screws. These screws should be torqued to 50 in./lbs. An interface wiring diagram for the 0-2 aircraft installation is shown on Figure 22 and for the OV-10 on Figure 23.

Section V
TESTING EVALUATION

General - The Lightweight Flare Dispensing System was evaluated during all stages of design and development beginning with engineering models through flight testing of a complete system. The nature and extent of the tests were intended to verify primary design performance of the system at the brassboard level of development. Table I below summarized these tests.

TABLE 1
Testing Summary

	Firing Mechanism Module	Dispenser Assembly	Control Unit
Design Test	Model	Mockup	Breadboard
Functional Test	1000 Cycles	100 Cycles	100 Cycles
Vibration Test	15g	-	-
Shock Test	20g	-	-
High Temperature Test	165°F	-	-
Low Temperature Test	-65°F	-	-
Ground Test	-	60 Flares	3 Cycles
Flight Test	-	60 Flares	4 Missions

Design Testing and Functional Tests - Testing began with engineering models of the gun mechanism assembly and breadboard circuits of the control unit.

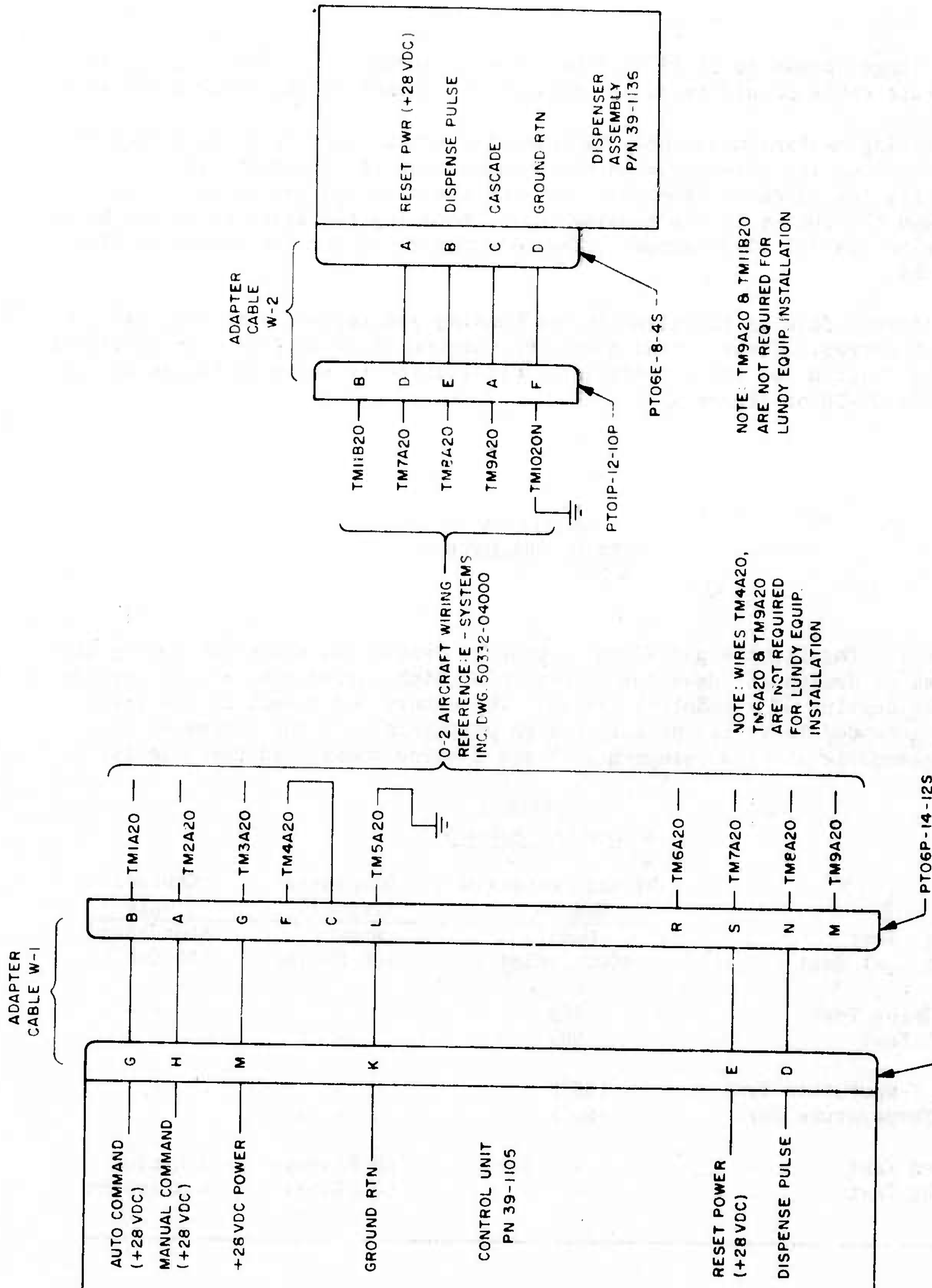

Figure 22 - 0-2 AIRCRAFT INTERFACE WIRING DIAGRAM

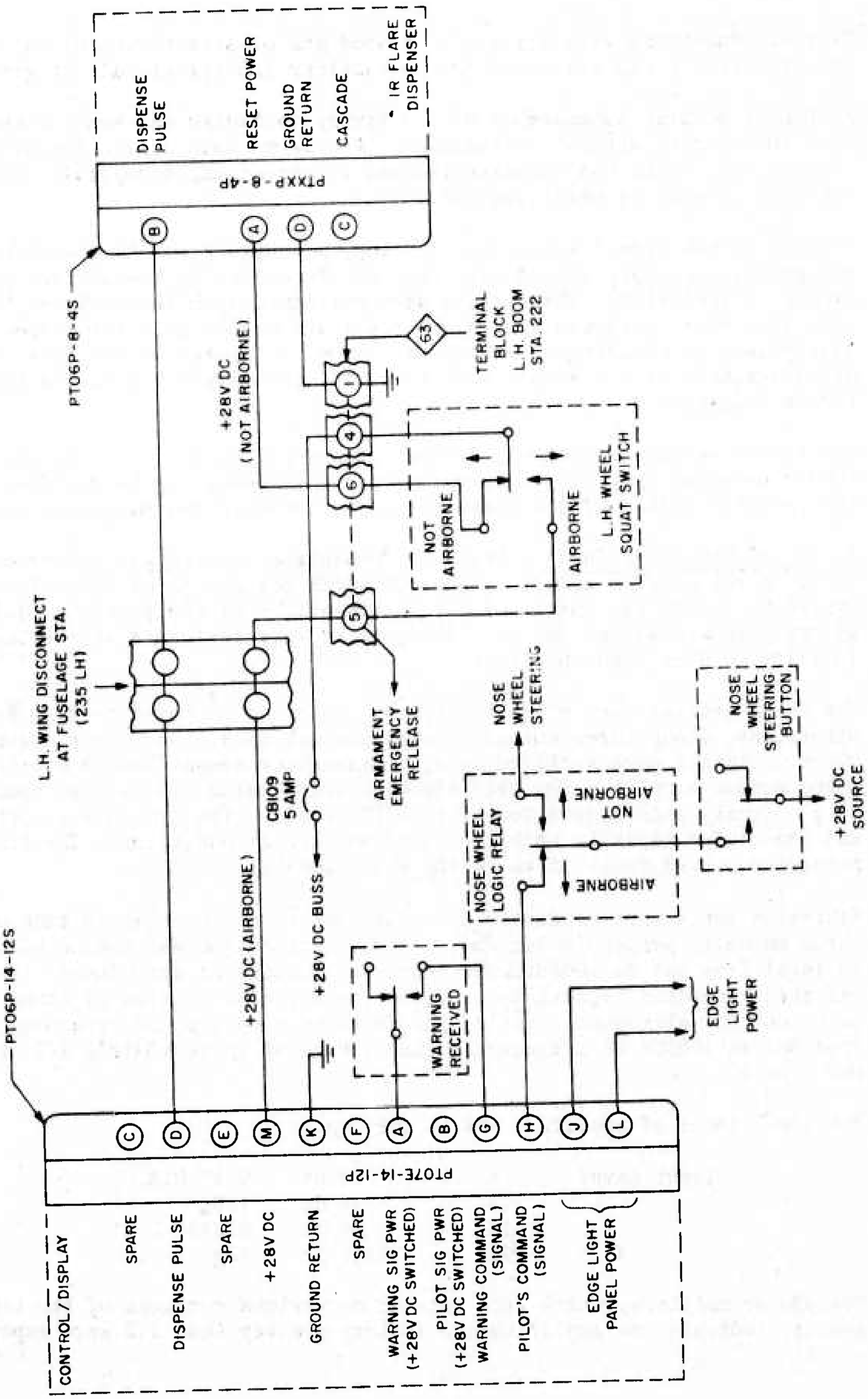

Figure 23 - OV-10 AIRCRAFT INTERFACE WIRING DIAGRAM

Critical functions were verified. A wood and plastic mockup of the dispenser assembly was evaluated for operability and structural integrity.

A 10-unit modular subassembly of the firing mechanism was bench tested over 1000 cycles without malfunction. Following this cyclic functional testing the module was disassembled and inspected microscopically for evidence of wear or metal fatigue.

As part of the normal acceptance testing, a complete system comprised of a dispenser assembly and control unit was functionally tested over 100 cycles of operation. These tests were performed with inert flares, however each test cycle included removal of the flare module from the dispenser assemblies, downloading of the inert flares, reloading of the inert flares and reassembly of the module into the dispenser assembly prior to the firing sequence.

The system performed properly throughout the 100 cycles of operation. It should be noted that proper operation, in this case, can be verified by the positive strike of the hammer/firing pin within the dispenser assembly.

Shock and Vibration Tests - Shock and vibration testing was performed early in the program effort, concurrent with the design of the overall system to verify the survivability/vulnerability of the firing mechanism assembly to mechanical forces. These tests were performed at the Lundy facility in Glen Head, New York.

The shock testing, per MIL-STD-810, was comprised of three shocks, in six directions, along three mutually perpendicular axes. The shock pulse characteristics were verified using a transducer sensor and an oscilloscope output display. The half sinewave shock pulse used was in excess of 15 g's (peak) with a duration of 11 millisecond. The system was cocked and loaded for tests in both the safed and armed conditions. The firing mechanism proved insensitive to the shock loading.

Vibration tests were conducted with the test module mounted in each of three mutually perpendicular axes. A resonant search was conducted at the 2g level from 5Hz to 1000Hz. No resonance conditions were found. The module was then subjected to continuous vibration for a total time of three hours in each mounting alignment. During the three hour period the frequency ranged from 5Hz to 1000Hz at a frequency change rate of approximately 1/2 octave per minute.

The input level of amplitude was as follows:

Input Level	5	-	14 Hz	0.1" D.A.
	14	-	23 Hz	1.0g
	23	-	90 Hz	0.036" D.A.
	90	-	1000 Hz	15g

Transducer monitors, which were located on various surfaces of the test module, indicated no amplification factors greater than 1.2 were experienced.

High and Low Temperature Testing - The firing mechanism module was functionally tested after soaking in an ambient temperature of +165°F for three hours, likewise after soaking for three hours at -65°F. Some change in the stepping motor response was noted at the high temperature, low voltage (24 VDC) condition, however, the response time was well within the 40 μ firing pulse.

The control unit was not tested at temperature extremes, however, its design and construction was very similar to control units which Lundy has previously qualified through all mechanical and thermal environments.

Flare Dispensing Tests - Live flares were fired from the dispensing system both on the ground and inflight. As part of the informal acceptance testing, 60 flares (3 module loads) were dispensed in a safe area at Lundy Technical Center. The flares were ejected under a variety of dispensing programs and the system performed with no malfunction.

The lightweight flare dispensing system was flight tested on an O-2 aircraft at Eglin AFB during October and November of 1974. A total of 60 flares were dispensed on 4 separate missions. The flight tests were highly successful in terms of proper function and tactical performance against simulated threat equipment. This flight testing is reported in detail in ADTC Report #ADTC-TR-74-118 (4 Dec 74).